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CSE

(54) Vaporizing heavy hydrocarbon feedstocks without coking

(57) A method for a vaporizing heavy hydrocarbon which avoids the formation of coke in the feed heaters and is useful in a process for upgrading and/or converting the heavy hydrocarbon to lighter products. Heavy hydrocarbon feedstock (10) is heated (12) to a temperature below its coking point, then mixed (at 20) with hydrogen (16) heated (at 18) to a temperature sufficient so that the hydrocarbon feedstock is vaporized without forming coke. Alternatively, the heavy hydrocarbon feedstock can be fractionated to provide a light IBP-550°F (288°C) liquid fraction, and a heavy 550-850°F (288 - 454°C) liquid fraction. The light fraction is mixed with hydrogen and heated to a temperature sufficiently high, so that upon being mixed with the heavy liquid fraction the latter is heated through its dry point and vaporized without coking. The resulting vaporized hydrocarbon is usually further heated before being fed to a reaction step, such as hydrodealkylation.

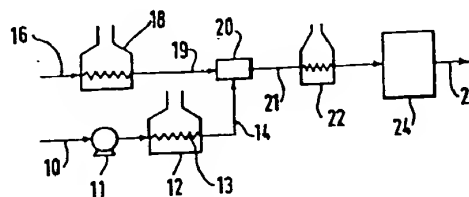


FIG.1.

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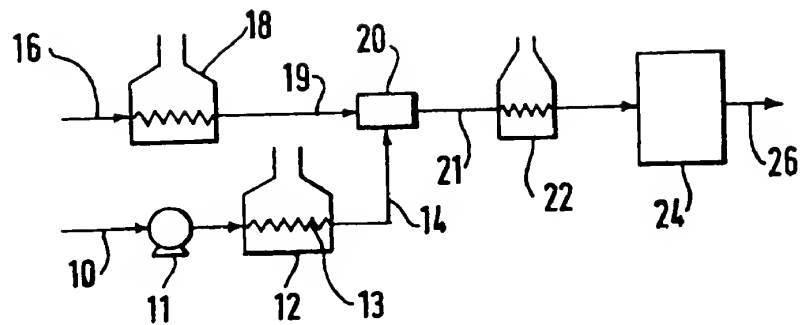


FIG. 1.

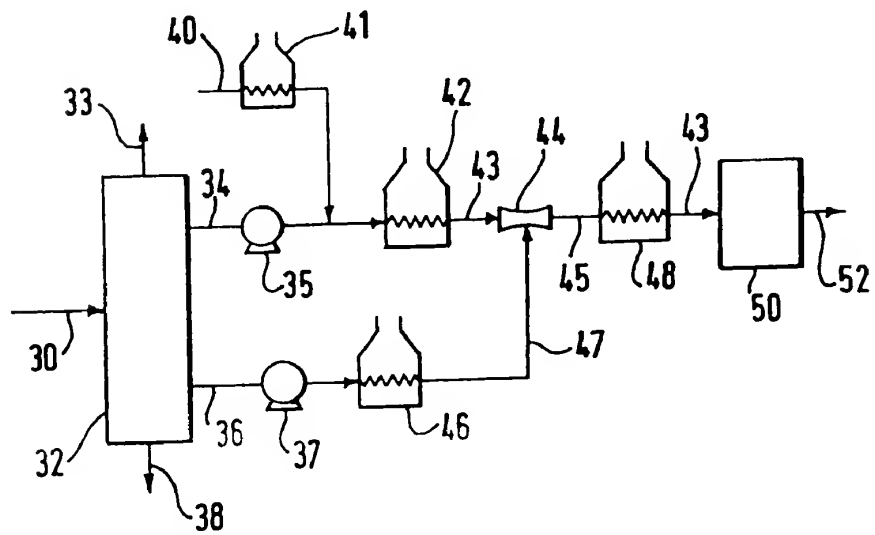


FIG. 2.

SPECIFICATION

Vaporizing heavy hydrocarbon feedstocks without coking

- 5 This invention relates to the heating and vaporizing of heavy hydrocarbon feedstock materials. More particularly, it relates to a method for providing a vaporized heavy hydrocarbon feedstock which avoids the formation of coke in the feed heaters useful in a process for upgrading and/or converting the heavy hydrocarbon to lighter products, such as in a thermal hydrodealkylation process.
- One barrier to successful hydrodealkylation of heavy hydrocarbon aromatic materials such as steam cracker tar to produce mono-ring product materials is vaporization of the liquid phase feed material without producing excessive coke formation during the preheating step. It has generally been found that such heavy hydrocarbon liquids when preheated to above 550°F (288°C) are susceptible to coking. To overcome this problem of undesired coke formation during preheating and to permit feeding heavier vaporized feedstock materials to thermal or catalytic reaction processes, it has been found possible to make
- 10 use of superheated hydrogen and/or hydrocarbon vapours mixed with the heavy hydrocarbon feed to rapidly heat and vaporize the heavy hydrocarbon liquids to provide a vapor phase material without coking of the heavy hydrocarbon feed material. Although it is known in industry to use preheated hydrogen mixed with feed liquids upstream of a reaction step, such heated hydrogen has apparently not been previously used to vaporize hydrocarbon heavy feedstock materials which contain constituents which are
- 15 prone to coking in a conventional tubular fired heater preheating step.
- This invention provides a method for providing a vaporized heavy hydrocarbon feedstock which avoids the formation of coke in the feed heaters useful in a process for upgrading and/or converting the heavy hydrocarbon to lighter products, such as in a thermal hydrodealkylation process. The method comprises heating a heavy hydrocarbon feedstock to a temperature below its coking temperature, heating hydrogen
- 20 to a temperature sufficiently above the temperature of the heated hydrocarbon feedstock and hydrogen together, the heavy hydrocarbon feed material is completely vaporized without forming any coke.
- In a second embodiment of the invention, a heavy hydrocarbon feedstock is first fractionated into a lighter fraction normally boiling below 550°F (288°C) and a heavier fraction having a normal boiling range of 550°F to 850°F (228 to 454°C). The heavier hydrocarbon fraction is heated to a temperature below its
- 25 coking point, and the lighter fraction and hydrogen are heated separately to a temperature below the coking point of the lighter fraction and sufficiently above the temperature of the heated heavy hydrocarbon fraction to provide a heat content sufficient that, upon being mixed with the heavy hydrocarbon fraction, the latter is vaporized without forming any coke.
- Using this invention, the temperature of the mixing chamber wall can be maintained at a significantly
- 30 lower temperature than would be required for the wall temperature of a tubular type fired preheater for vaporizing the feedstock.
- This invention for vaporizing heavy hydrocarbon feedstocks is useful at a pressure range of 50-5000 psig (3.4-345 bar gauge). The vaporized material stream can then be fed to a further reaction step such as hydrodealkylation to produce hydrodealkylated products.
- 35 In the present invention for vaporizing heavy hydrocarbon feedstocks, so as to avoid formation of coke, hydrogen is heated to a temperature sufficient that upon mixing with the heavy hydrocarbon feedstocks will effectively heat same through their dry point and vaporize the heavy feedstock without coking. The heated hydrogen is mixed with the heavy feedstock in a suitable mixing step such as a venturi mixer. The temperature of the heated hydrogen is much higher than the temperature of the heavy hydrocarbon
- 40 feed material, and is sufficiently high, such as 900-1250°F (482-677°C), that it supplies all the heat needed to vaporize the heavy liquid feedstock, which normally boils above 550°F (288°C) and preferably has a boiling range of 550-650°F (288-343°C). Because of the rapid heat transfer which occurs between the mixed streams in the mixing step, this heating method avoids transferring heat from a hot wall to the hydrocarbon feedstock and minimizes the time required to vaporize the heavy feed material and avoids
- 45 coking of the material.
- In a second embodiment of the invention, the hydrogen can be premixed with a light hydrocarbon fraction having a normal boiling range of 400-650°F (204-343°C) and heated together to a temperature below the coking point of the light hydrocarbon fraction and sufficient that, upon mixing with the heavy hydrocarbon feedstock fraction, will rapidly heat same through its dry point and completely vaporize the
- 50 heavy hydrocarbon feedstock without coking of the heavy hydrocarbon feedstock material.
- This invention can be used for vaporizing any heavy hydrocarbon feed material for which a vapour phase reaction is required, such as for vaporizing heavy gas oils and steam cracker tar derived from petroleum, and coal-derived liquids, prior to feeding the vaporized hydrocarbon material to a further reaction step such as thermal hydrocracking or hydrodealkylation to produce hydrodealkylation products.
- 55 Useful pressure ranges for the invention are 50-5000 psig (3.4-345 bar gauge) and preferably 200-1000 psig (13.8-69 bar gauge).

Reference is now made to the accompanying drawings, in which:

Figure 1 is a flow diagram illustrating a method for vaporizing a heavy hydrocarbon feedstock according to the present invention; and

65 Figure 2 is a flow diagram of a second embodiment of the method illustrated in Figure 1.

As shown in the Figure 1 drawing, a heavy hydrocarbon feedstock material such as heavy gas oil, is provided at 10, pressurized at 11 to at least about 200 psig (13.8 bar gauge) and heated in furnace 12 to a temperature such as about 560°F (293°C), which will not produce coke deposits inside the tubes 13 of the furnace. The heated feedstock stream at 14 is passed to a mixing step at 20. Also, hydrogen gas is provided at 16 and heated in furnace 18 to a temperature well above temperature of the mixing step 20 and also passed via line 19 to the mixing step.

Mixing step 20 may comprise any suitable known mixing device which provides complete mixing at relatively high velocities, such as a length of pipe, nozzle or venturi, with the heavy oil stream 14 preferably being introduced into the throat section of a venturi. The heat content provided in hydrogen stream 19 is sufficient to completely vaporize the heavy hydrocarbon feed stream 14, and thus avoids heating the hydrocarbon feedstock through its dry point by contact with a hot metal wall maintained at higher temperature and thereby prevents any coking of the heavy feed material during such heating.

The resulting vaporized material at 21 is further heated in heater 22 to about 1250°F (677°C) and passed to a further reaction step 24, such as for a hydrodealkylation process, to produce a product 26.

In an alternative embodiment of the invention, as shown in Figure 2, a heavy feedstock material such as steam cracker tar is provided at 30 and fed into fractionation tower 32, which is usually maintained at operating conditions of about 200-300°F (93-149°C) temperature and 1-5 psia (0.069-0.345 bar absolute) pressure. From tower 32, a vapor stream can be withdrawn at 33, a light liquid stream boiling up to about 550°F (288°C) is withdrawn at 34, a heavy liquid stream having a boiling range of 550-850°F (288-454°C) is withdrawn at 36, and a heavier bottoms material boiling above about 850°F (454°C) is withdrawn at 38.

The light liquid stream 34 is pressurized at 35 to at least about 200 psig (13.8 bar gauge), hydrogen is added at 40 and heated at 41, and the resulting mixture is heated in heater 42 to a temperature above about 950°F (510°C) and passed as stream 43 to mixing step 44, which can advantageously comprise a venturi mixing device having a reduced pressure and increased flow velocity at its throat section. The heavy boiling liquid stream 36 is pressurized at 37 to at least about 200 psig (13.8 bar gauge), heated at 46 to a temperature sufficiently low to avoid coking in the tubes of heater 46, such as about 550°F (288°C), and also passed to the throat section of the venturi mixing step 44. The heat provided in stream 43 is sufficient to vaporize liquid stream 47, so that the resulting mixed stream which emerges at 45 from mixer 44 is completely vaporized. This vapor stream 45 is then passed through heater 48 for further heating such as to 1200-1250°F (649-677°C) temperature before passing to further reaction step 50, which may preferably be a hydrodealkylation step. If the feedstock at 30 is a polynuclear aromatic or polyalkylated phenol material, the light liquid stream at 34 can contain mainly alkylated naphthalene material, which is heated with hydrogen at 42 to a temperature sufficient so that upon being mixed with the heated heavy stream 47, which can be mainly alkylated phenanthrenes, the latter is completely vaporized. The resulting vaporized material is then fed to a hydrodealkylation reaction process step at 50 to produce product at 52.

This invention will be further described by reference to the following Examples, which should not be construed as limiting the scope.

Example 1

To show the method and utility of the present invention, a heavy hydrocarbon feed material such as gas oil normally boiling above about 600°F (316°C) temperature is pressurized to about 650 psia (45 bar gauge) pressure and heated to a temperature of at least 600°F (316°C) but below which any coking of the feed occurs. The heated feed material is then vaporized by being mixed with a hydrogen stream heated to a temperature sufficiently above the mixing temperature to have a heat content sufficient that, upon being mixed with the heavy liquid feed, will completely vaporize the feed with coking. The molar flow ratio of hydrogen to feed liquid is about 13, and the hydrogen stream contains 90% hydrogen and 10% methane. Results of the heating and mixing steps for various hydrocarbon feed stock fractions are shown in Table 1.

TABLE 1

Vaporizing hydrocarbon feedstock by mixing with heated hydrogen

Liquid Feedstock Avg. BP, °F(°C)	Liquid Feed Temp, °F(°C)	H ₂ Temp, °F(°C)	Mixing Temp, °F(°C)
600 (316)	600 (316)	1000 (538)	690 (366)
650 (343)	600 (316)	1125 (607)	735 (391)
700 (371)	650 (343)	1250 (677)	803 (428)

It is seen that the heavy hydrocarbon feed materials having average boiling points between 800 (316°C) and 700°F (371°C) can be heated and completely vaporized without coking by being mixed with a hydrogen stream heated to a higher temperature but not exceeding 1250°F (677°C) to provide a hydrocarbon vapor material.

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Example 2

A heavy hydrocarbon feed material such as steam cracker tar is fractionated into at least eight fraction having a normal boiling range of 300-550°F (149-288°C) and a heavy fraction having a boiling range of 550-850°F (288-454°C). The heavy hydrocarbon fraction is heated to a temperature below its coking point and passed to a mixing step. The light fraction stream is mixed with heated hydrogen and the resulting stream is heated to a temperature higher than that of the heavy fraction and such as to provide a heat content sufficient that, upon mixing the two preheated hydrocarbon streams together, the heavy hydrocarbon stream is completely vaporized without any coking. Results of the heating and mixing steps for various hydrocarbon feedstocks at 650 psi (45 bar) using 13 moles hydrogen, 1 mole light hydrocarbon fraction and 1 mole heavy hydrocarbon fraction feed are shown in Table 2.

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TABLE 2

Vaporizing heavy hydrocarbon fraction by mixing with heated hydrogen and light hydrocarbon fraction

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Liquid Feedstock Avg. BP, °F (°C)	Heavy Liquid Feed Temp, °F (°C)	Light Liquid and H ₂ Temp, °F (°C)	Mixing * Temp, °F (°C)
600 (316)	600 (316)	1000 (538)	830 (443)
650 (343)	600 (316)	1000 (538)	825 (441)
700 (371)	600 (316)	1000 (538)	820 (438)

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* Temperatures are $\pm 30^\circ\text{F}$.

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It is seen that the heavy hydrocarbon feedstocks having initial boiling points between about 600-700°F (316-371°C) can be heated and completely vaporized without coking by being mixed with a light hydrocarbon liquid fraction and hydrogen mixture heated to a temperature sufficiently above the mixing temperature, but not exceeding about 1000°F (538°C), to heat and vaporize the heavy feedstock and provide a hydrocarbon vapor material.

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CLAIMS

1. A method for providing a vaporized heavy hydrocarbon feedstock which avoids the formation of coke in the feed heaters and is useful in a process for upgrading and/or converting said heavy hydrocarbons, said method comprising:
 - (a) heating a heavy hydrocarbon feedstock to a temperature of at least 500°F (260°C) but below its coking point;
 - (b) heating hydrogen to a temperature sufficiently above the temperature of said heated heavy hydrocarbon feedstock so as to provide a heat content sufficient to vaporize said heated heavy hydrocarbon feedstock; and
 - (c) mixing said heated heavy hydrocarbon feedstock together with said heated hydrogen and vaporizing the heavy hydrocarbon feedstock to provide a hydrocarbon vapour material without forming coke.
2. A method according to claim 1, wherein said heavy hydrocarbon feedstock is heated to a temperature of 550-650°F (288-343°C).
3. A method according to claim 1 or 2, wherein said hydrogen is heated to a temperature of 1000-1250°F (538-677°C).
4. A method according to any of claims 1 to 3, wherein the heavy hydrocarbon feedstock is steam cracker tar derived from petroleum.
5. A method according to any of claims 1 to 3, wherein the heavy hydrocarbon feedstock is a coal-derived liquid.
6. A method according to any of claims 1 to 5, wherein said mixing step occurs in a venturi device.
7. A method according to any of claims 1 to 6, wherein the mixed and vaporized hydrocarbon material and hydrogen are further heated to a temperature above the vaporization temperature of said heavy hydrocarbon feedstock.
8. A method according to claim 7, wherein said heated mixture of vaporized hydrocarbon material

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and hydrogen is fed into a hydrodealkylation reaction step to produce a hydrodealkylated product.

9. A method for providing a vaporized heavy hydrocarbon feedstock which avoids the formation of coke in the feed heaters and is useful in a process for upgrading and/or converting said heavy hydrocarbon, said method comprising:

- 5 (a) fractionating a heavy hydrocarbon feedstock into a light fraction having a normal boiling temperature below 550°F (288°C) and a heavy fraction having a normal boiling temperature range of 550 to 850°F (288-454°C);
- (b) heating said heavy hydrocracking fraction to a temperature of at least 500°F (260°C) but below its coking point;
- 10 (c) heating hydrogen and said light hydrocarbon fraction to a temperature sufficiently above the temperature of said heated heavy hydrocarbon fraction to avoid coking the light hydrocarbon fraction and provide a heat content sufficient to vaporize said heavy hydrocarbon fraction; and
- (d) mixing said heated heavy hydrocarbon fraction together with said hydrogen and light hydrocarbon fraction to vaporize the heavy hydrocarbon fraction and provide a hydrocarbon vapour material without
- 15 forming coke.
10. A method according to claim 9, wherein said heavy hydrocarbon fraction is heated to a temperature of 550-650°F (288-343°C).
11. A method according to claim 9 or 10, wherein said hydrogen and light hydrocarbon fraction are heated together to a temperature of 1000-1250°F (538-677°C).
- 20 12. A method according to any of claims 9 to 11, wherein said fractionation step occurs at vacuum pressure.
13. A method according to any of claims 9 to 12, wherein the heavy hydrocarbon feedstock is steam cracker tar derived from petroleum.
14. A method according to any of claims 9 to 12, wherein the heavy hydrocarbon feedstock is a coal-
- 25 derived liquid.
15. A method according to any of claims 9 to 14, wherein said mixed and vaporized hydrocarbon fractions and hydrogen are further heated to a temperature above the vaporization temperature of said heavy hydrocarbon feedstock.
16. A method according to claim 15, wherein said heated mixture of vaporized hydrocarbon feedstock
- 30 and hydrogen is fed into a hydrodealkylation reaction step to produce a hydrodealkylated product.
17. A method according to claim 1, substantially as hereinbefore described with reference to Figure 1 and/or Example 1.
18. A method according to claim 9, substantially as hereinbefore described with reference to Figure 2 and/or Example 2.
- 35 19. Hydrocarbon products produced by a method according to any of claims 1 to 18.